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"ARE MIGRANTS MORE PRODUCTIVE THAN STAYERS? SOME EVIDENCE FOR A SET OF HIGHLY PRODUCTIVE ACADEMIC ECONOMISTS"

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Abstract

This paper compares the average productivity of migrants (who work in a country different from their country of origin) and stayers (whose entire academic career takes place in their country of origin) in a set of 2,530 highly productive economists that work in 2007 in a selection of the top 81 Economics departments worldwide. The main findings are the following two. Firstly, productivity comparisons between migrants and stayers depend on the cohort and the type of department where individuals work in 2007. For example, in the top U.S. departments, foreigners are more productive than stayers only among older individuals; in the bottom U.S. departments, foreigners are more productive than stayers for both cohorts, while in the other countries with at least one department in the sample the productivity of foreigners and stayers is indistinguishable for both cohorts. Secondly, when we restrict our attention to an elite consisting of economists with above average productivity, all productivity differences between migrants and stayers in the U.S. vanish. These results are very robust. However, our ability to interpret these correlations is severely limited by the absence of information on the decision to migrate.

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I. INTRODUCTION

In all sciences, researchers originate from many countries. However, when we focus on the most productive and influential researchers we observe that a large contingent of scientists working in the top U.S. research institutions have obtained their first college degree in their country of origin.[1] Understandably, this situation can be described as a case of what Hunter *et al.* (2009) calls the *elite brain drain* –a worrisome phenomenon from the point of view of the sending countries. However, there is a second group of scientists who study and/or work abroad followed by a return to the home country –a phenomenon known as *brain circulation*. Such people return home with the human capital they would have not acquired if it were not for the possibility of temporary emigration.[2] Therefore, it is convenient to partition scientists born in any country into three groups: brain drain, brain circulation –which will be referred to as *movers*– and *stayers*, who are those who study and work in their country of origin.

This paper studies movers and stayers in a set of 2,530 highly productive economists that work in 2007 in the top 81 Economics departments worldwide according to the Econphd (2004) ranking. Not surprisingly, 52 out of the 81 departments in our sample are located in the U.S. There are only eleven countries with at least one of the remaining 29 non-U.S. departments in the sample. We refer to them as the Other Sample Countries (OSC hereafter). We measure individual productivity in terms of a quality index that weights the number of publications from the beginning of everyone's career up to 2007 in four equivalent journal classes. We use different weighting schemes leading to different productivity measures. Individual productivity in all scientific fields is known to be highly skewed (see Ruiz-Castillo & Costas, 2015). This is also the case for all productivity measures used in this paper.

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[1] See *inter alia* Ioannidis (2004), Bauwens *et al.* (2008), and Panaretos & Malesios (2012). For a detailed analysis of the characteristics of highly productive researchers in economics, see our companion paper Albarrán *et al.* (2014a).

[2] For the economics of immigration, see Borjas (1999) and Stark (2005), and for a survey of four decades of economics research on the brain drain, see Doquier & Rapoport (2012). Specifically, for the elite brain drain, see Zuckerman (1977), Stephan & Levin (2001), Weinberger & Galeson (2005), Laudel (2003, 2005), and the references in note 1. For brain circulation, see *inter alia* Borjas & Bratsberg, 1996, Grogger & Hanson, 2013, and Kahn & MacGarvie, 2016.

In this scenario, our main aim is to study whether the productivity of foreigners is greater or not than the productivity of stayers both in the U.S. and the OSC.[3] This is an interesting question for several reasons. Firstly, as we have said, brain drain is an important phenomenon in all sciences. In our dataset, the proportion of migrants working in 2007 in the U.S. or the OSC is 41.1% and 38.5%, respectively. For the understanding of the academic sector, we would like to know whether migrants are more productive than stayers. Secondly, this question is relevant for the design of immigration/emigration policies. For example, from a world welfare point of view, if it were the case that migrants are generally more productive than stayers, then there are reasons to defend the validity of policies aimed at facilitating increased brain exchange across countries (Franzoni *et al.*, 2014). Naturally, as we will see in the discussion section, this is not the only point of view to be considered.

As is well known, the unobservable ability of individuals is correlated both to migration and to performance. But our productivity comparisons are obtained with retrospective data concerning economists' mobility and aggregate productivity up to 2007. Thus, in the absence of information for correcting the typical positive selection into migration among the high skilled, the endogeneity of individuals' locational choice makes a causal interpretation of our results impossible. In this situation, we are restricted to searching for robust correlations capturing some new stylized facts worth investigating further in economics and other scientific disciplines. With this purpose in mind, the following three considerations guide our empirical strategy.

1. Our measure of aggregate productivity up to 2007 favors older people. Therefore, it is essential to control for experience or (academic) age effects. In addition, we study cohort effects for different definitions of the distinction between young and older individuals. Demographic variables –age, cohort, and gender effects– account for a large proportion of the variance of individual productivity.

[3] In Albarrán *et al.* (2014b), we also study a different question from the perspective of the sending countries: are movers –brain drain and brain circulation– from the OSC (or the U.S.) more productive than OSC (or U.S.) stayers?

2. We observe the existence of *department effects* in the U.S., in the sense that when we partition the 52 U.S. departments into several categories according to their prestige –say, top, intermediate, and bottom categories–, the average productivity of economists working in each category is hierarchically ordered. A proper interpretation of this result requires discussing whether higher performing universities contribute to the productivity of individual researchers and/or whether they simply attract more productive individuals. As already noted, our data does not allow us to address this question. However, the literature concerning the inexistence of geographically based spillover effects (Han Kim *et al.*, 2009, Azoulay *et al.*, 2010, Waldinger, 2012, Borjas & Doran, 2014, and Dubois *et al.*, 2014) leads us to suggest that department effects are essentially due to self-selection on the supply side, and the role of meritocratic criteria on the demand side of a highly competitive market. Be that as it may, a key lesson for our purposes is that productivity comparisons between foreigners and stayers in the U.S. must be made conditional on such department effects.

Our preferred specification consists of the double partition of departments into three categories –top U.S. departments, bottom U.S. departments, and OSC departments– and individuals into two cohorts of young and older people. In this specification we make six productivity comparisons between foreigners and stayers. In all cases, we control for a relatively rich set of career variables, namely, the university where each individual earns her B.A., her Ph.D., and the university where each holds her first job.

3. The results in the literature concerning the existence of productivity differences between migrants and nationals in the U.S. academic sector are mixed. Independently of the fact that different studies use different methodologies, as well as different productivity measures for scientists in different fields during different time periods, there are also important differences in the characteristics of the group to whom migrants are compared. For example, Hunter *et al.* (2009) study a small sample of 138 highly cited researchers writing in physics journals between 1981 and 1999. Using a simple formal model, their main conclusion is that, due to low mobility costs, the distribution of talent can be expected to be similar across

different countries, so that foreigners who move to the U.S. go on to be neither more nor less distinguished than American-born elite physicists. This contradicts the results from two important contributions whose datasets consist of more than 2,500 Ph.D. economists working in the U.S. (McDowell & Singell, 2000), or more than 14,000 retrospective questionnaires in several sciences (Franzoni *et al.*, 2014). Both studies find that, after controlling for the endogeneity of the migration decision, migrant scientists exhibit superior performance.[4]

Given any ordered individual productivity distribution, consider the possibility of restricting the attention to some subset of researchers in the upper tail of the distribution. We refer to such subset as the *elite*. In this paper, we establish that when we make such a move in the Hunter *et al.* (2009) model the productivity of elite migrants converges to the productivity of elite stayers. In view of the disparity of results for samples of very different nature in the literature, and in view of our extension of the Hunter *et al.* (2009) model, we find it interesting to make all of our productivity comparisons for the entire population consisting of 2,530 economists, and an elite consisting of 833 individuals with above average productivity. Furthermore, given the high skewness of individual productivity, restricting attention to what happens at the upper tail of the distribution is an interesting research option. Our main results are the following.

• In the top 25 U.S. departments, the productivity of foreigners in the total sample is greater than the productivity of stayers only among the older individuals. Among the young, the productivity of the two groups is indistinguishable.

• In the bottom 27 U.S. departments the situation is very different. The key feature is the very low productivity of both young and older stayers in the total sample. Thus, migrants are more productive than stayers in both cohorts in this sample.

[4] The same conclusion is reached by Ruhose *et al.* (2015) for 565 high-skilled German immigrants *versus* 289,538 high-skilled U.S. natives. However, rather than Ph.D. holders working in the U.S. academic sector, the high-skilled in this paper are individuals with a B.A. or higher degree who work in any type of full-time job in the U.S.

• In agreement with our extension of the Hunter *et al.* (2009) model, all productivity differences between foreigners and stayers in the U.S. vanish in the elite.

• In the OSC departments, the productivity of foreigners and stayers in the two cohorts is indistinguishable both in the total sample and the elite.

A remarkable aspect of these findings is that they are robust in the following four directions: (i) the partition of the 81 departments into three or more categories, (ii) the treatment of the elite, (iii) the definition of the two cohorts, and (iv) the weighting scheme used in the construction of the productivity measure.

The rest of the paper consists of four Sections and two Appendices. Section II presents the data, as well as some descriptive statistics. Section III describes the sequence of estimates leading to our preferred specification, and presents the key empirical results comparing the productivity of migrants and stayers in the total sample and the elite controlling for demographics and career variables. Section IV studies the robustness of the results. Section V includes a summary of the paper, a discussion of the main findings, some policy considerations, and some concluding comments on further research. Appendix I includes some statistical material, and Appendix II discusses the Hunter *et al.* (2009) model.

II. DATA, THE MEASUREMENT OF PRODUCTIVITY, AND THE ELITE NOTION

II.1. The data

In this Sub-section, we briefly describe a dataset that was originally constructed to study the elite in economics (Albarrán *et al.*, 2014a). In the first place, we select faculty members in the top 81 departments worldwide according to the Econphd (2004) university ranking. This ranking takes into account the publications in the period 1993-2003 in the top 63 Economics journals in the Kalaitzidakis *et al.* (2003)

weighted journal ranking, where the weights reflect journal citation counts adjusted for factors such as the annual number of pages and the age of the journal (for further methodological details, see Econphd, 2004).[5]

Searching in the 81 departmental web pages in 2007, we found a total of 2,705 economists with the minimum information we require for each individual: nationality, university where a Ph.D. is obtained, age, and publications in the periodical literature up to 2007. The information concerning the country of birth is seldom available. Therefore, we assign the nationality in terms of the country where each individual obtains a B.A. or an equivalent first college degree.[6] Similarly, since an individual's age is not generally available we use the academic age, namely, the number of years elapsed since earning a Ph.D. (or equivalent degree) up to 2007.

II.2. The measurement of individual productivity

We take information available in Internet (personal web pages, *RePEc*, *Publish or Perish*, etc.) on publications up to 2007 of these 2,705 people. Because of budgetary restrictions, our information on productivity suffers from two limitations. Firstly, the article count in our dataset made no distinction between single and multiple-authorship. Consequently, no correction for co-authorship could be implemented. Nevertheless, there is evidence that the average number of authors per article in Economics & Business in 2003-2011 is 1.8, whereas the mean and standard deviation for 30 broad scientific disciplines is 3.1 and 1.1 (Ruiz-Castillo & Costas, 2014, Table III, Appendix B). Therefore, under the assumption that the assignment of equal responsibility for co-authored publications is a more acceptable assumption when the number of authors per publication is small, our practice of assigning full credit for all publications to

[5] We have compared this list with the first 81 economics departments listed in three other equally acceptable university rankings. The main conclusion is that, apart from differences in the order in which each institution appears in the various rankings, our list has between 70 and 73 departments in common with each of the three other lists (see Albarrán *et al.*, 2014a for further details). On the other hand, the Econphd (2004) department ranking is also used in Oyer (2006).

[6] Consider the case of a foreigner earning her B.A. in a U.S. institution who works in the U.S. in 2007. She will be classified as a U.S. stayer. Quite apart from the fact that we do not have the means to learn about her true nationality, in so far as this person does not consume national resources in her college education, there are reasons to classify her as a U.S. stayer.

each author, independently of whether they are co-authored or not, is a lesser problem in our case. Secondly, although we know the journal where each article is published, it was impossible to search for the citation impact achieved by every article. Therefore, we are constrained to measuring individual productivity as a function of the total number of publications per person over her academic career up to 2007.

In every science, there is broad agreement about the different merit associated to publishing in a reduced number of top journals, a larger set of excellent field journals, or the remaining international or local journals. Although any specific classification will always be controversial, a consensus on how to weight the different journal classes in order to reach a scalar measure of productivity is possibly even harder to reach.

Starting from the top 63 journals in the Kalaitzidakis *et al.* (2003) journal ranking, and taking also into account the rankings in Lubrano *et al.* (2003), and Kodrzycki & Yu (2006), in this paper we distinguish between four journal classes.[7] In our preferred weighting scheme, the four classes are assigned weights equal to 40, 15, 7, and 1 point, respectively. The resulting quality index is denoted by $\mathcal{Q}$. Being aware that this option might be objected to for being too elitist, we study the robustness of our findings using two other productivity indices. The first one, denoted by $\mathcal{Q}'$, assigns weights equal to 20, 10, 5, and 1 point to the four classes. The last index, denoted by P, weights equally all classes, i.e. it measures individual productivity as the total number of publications. Table A in Appendix I includes the listing of the 81 departments, together with information for each institution concerning the number of faculty members (including Emeritus Professors), the number of people without publications, the remaining scholars' publications in classes A to D, and the department value of indices $\mathcal{Q}$, $\mathcal{Q}'$, and P. The OSC consist of eight European countries (UK,

[7] Classes A, B, and C consist of 5, 34, and 47 journals, while class D consists of any other journal. Class A includes the *American Economic Review*, *Econometrica*, *Journal of Political Economy*, *Quarterly Journal of Economics*, and *Review of Economic Studies*. By way of example, the following 12 journals are in class B: *Economic Journal*, *Games and Economic Behavior*, *International Economic Review*, *Journal of Econometrics*, *Journal of Economic Growth*, *Journal of Economic Theory*, *Journal of Finance*, *Journal of Labor Economics*, *Journal of Monetary Economics*, *Journal of Public Economics*, *Rand Journal of Economics*, and *Review of Economics and Statistics*. See Albarrán *et al.* (2014a) for further details concerning this construction.

the Netherlands, Spain, Sweden, France, Germany, Belgium, and Denmark), and three non-European countries (Canada, Israel, and China).

II.3. The total sample versus the elite

Out of the 2,705 economists in our dataset, there are 175 faculty members without any publications at all (typically because they are on tenure track). In line with the previous literature on individual productivity, in the sequel we focus on what we call the *total sample* consisting of the 2,530 faculty members with at least one publication.

For reasons that will be apparent in a moment, consider the partition of productivity distributions in the total sample into three categories according to the following scheme. Let μ_1 be the mean of any productivity distribution, and let μ_2 be the mean productivity of individuals with productivity greater than μ_1. The three categories consist of individuals with productivity (i) less than or equal to μ_1, (ii) between μ_1 and μ_2, and (iii) above μ_2. The information concerning the two means, the proportion of people in the three categories, as well as the proportion of the total productivity accounted for by each category is in Table 1.

Table 1 around here

The following two characteristics of productivity distributions are worth noting. Consider index Q. Firstly, the 2,530 individuals in the total sample are very productive: average productivity is 307.3 quality points *per capita*, equivalent to more than seven articles of class A or about 20 articles of class B. Alternatively, the average quality index is 16.1 per year during an academic life (the period from the first year after receiving a Ph.D. up to 2007), a quantity that can be compared with the 15 points assigned to one article in class B. Secondly, the distribution of individual productivity is highly skewed: the average productivity is 17 percentage points above the median, and the top 11.5% in category 3 account for 43.6%

of all quality points.[8] In this context, we find it useful to define the *elite* as consisting of the 833 individuals with above average productivity in categories 2 and 3.

Note that the characteristics of productivity distributions *Q'* and *P* are very similar to the characteristics of distribution *Q*. In particular, the mean productivity of *Q'* is equivalent to more than nine articles in class A, whereas the mean productivity of *P* is equal to 27 publications. On the other hand, we define the elite notion for distributions *Q'* and *P* as we did for distribution *Q*. Since the two new distributions exhibit essentially the same skewness as distribution *Q*, the corresponding elites are of the same order of magnitude as before: 843 for index *Q'*, and 835 for index *P*.

III. EMPIRICAL RESULTS

III.1. Specification issues in the total sample

In this Sub-section, we introduce our preferred specification for the total sample when individual productivity is measured by the *Q* index. Given the high skewness of the individual productivity distribution, the dependent variable in the sequel is always the log of the *Q* index.

We proceed in three steps. Firstly, we analyze the important role of demographic variables (age and gender). Secondly, we focus attention on the comparison of the productivity of foreigners and stayers in the U.S. and the OSC, controlling for two types of variables: department effects in the U.S., and a number of other career variables, namely, the university where each individual earned her B.A. and her Ph.D., as well as the university where she held her first job. Thirdly, we study how best to interact the migrant/stayer condition with department effects and vintage variables. The definition of all explanatory variables will be presented in due order below. Descriptive statistics for the total sample are included in the left-hand panel in Table 2, where the reference group for any set of dummy variables is marked with an asterisk.

[8] Interestingly, these figures are of the same order of magnitude as those found in Ruiz-Castillo & Costas (2015) who study the productivity of 17.2 million authors in 30 broad scientific fields with publications in the period 2003-2011.

Table 2 around here

Demographic variables

As indicated in the Introduction, our measure of aggregate productivity up to 2007 favors older people. Together with the variable *Age* and $(Age)^2$, we introduce a dummy variable, *Young*, that takes the value one for young people, defined as those who earn a Ph.D. at most 20 years before 2007. Taking into account that the median age for finishing a Ph.D. is approximately 30 (Scott & Sigfried, 2008), young people in our sample are those with at most 50 years of age in 2007. They represent approximately half of the total sample. To account for the possibility that the productivity effect of one more year of academic experience is different for young and older individuals, our specification includes an interaction between the cohort and the age variables. Finally, the dummy variable *Female* takes the value one for females. Thus, *model 1* is the following:

$$Log\,Q = \alpha_0 + \alpha_1 Age + \alpha_2 Age^2 + \alpha_3 (Age \text{ x } Young) + \alpha_4 (Age^2 \text{ x } Young) + \alpha_5 Young + \alpha_6 Female + \varepsilon. \qquad (1)$$

Regression results for this model, as well as age, cohort, and gender effects are in the left-hand panel of Table 3.

Table 3 around here

The six variables of the model are highly significant. In agreement with human capital models, we find a humped-shaped progression of individual research productivity with academic age because the stock of human capital needs to be built up at the beginning of the career while, due to the finiteness of life, no new investment offsets depreciation and net investment declines (eventually) over time. Moreover, the young are more productive than the old and the young productivity gap of the young increases with experience. Finally, females –representing 14% of the total sample– are 57.9% less productive than males. At any rate,

age, cohort, and gender effects account for a large proportion of the variance: the adjusted R^2 in model 1 is 0.44.[9]

In order to test how robust age and cohort effects are to the cohort definition, we experiment with two other specifications: the variable *Young* takes the value one when *Age* is less than or equal to 15 or 24, so that young people are individuals with at most 45 or 54 years of age in 2007. The percentage of young people becomes 45.8% and 67.1%, respectively (Panel A in Table 2). Regression results for model 1 are in Table 3. Except for *Young* in the last specification, all variables are again highly significant. Age and gender effects are practically the same as before. The only difference concerns cohort effects: being young is somewhat more important than before for the smaller subset of young people in the second specification, whereas it becomes negative for the larger subset of young people in the third specification. Nevertheless, the productivity gap between young and older people increases with experience in all cases. Judging from the adjusted R^2, the importance of age, cohort, and gender effects is as large as before.

In view of these results, we continue the analysis with the cohorts' original definition. Nevertheless, in Section IV.3 we study the robustness of our key results with respect to alternative cohort specifications.

Foreigners versus stayers: a first approximation

The 81 departments in the sample are classified into Top and Bottom institutions using the Econphd department ranking (Table A in Appendix I). We begin by defining the former as the 25 top U.S. departments (that practically coincide with the top 25 departments in the world). Among the Bottom institutions, we distinguish between two categories: the last 27 U.S. departments, and the 29 non-U.S. departments located in the OSC.[10] Group sizes are in Panel B in Table 2. We should emphasize that the two Bottom groups are heterogeneous categories with a large overlap in terms of the Econphd department

[9] Interestingly, "*Years since Ph.D. accounted for 43% of the variance of log(total citations), 48% of the variance in log(h), 36% of the variance in log(e), and 54% of the variance in log(h_m) [e and h_m are variants of the h index]*" (Nosek *et al.*, 2010, p. 1287).

[10] Of course, which departments are in the "top 10", "top 25" or "last 27" at any moment is open to debate. Moreover, even if this classification is appropriate for the period 2004-2007, individual departments are likely to have changed positions over the period of this study prior to 2007. Therefore, it is advisable to take this partition as representative of "top" or "bottom" departments in general.

ranking.[11] It should be noted that in Section IV.3 we explore the consequences of considering a partition into five department categories: on one hand, among the first 25 U.S departments we distinguish between the top 10 and the next 15 U.S. departments whereas, on the other hand, we distinguish between the departments in Canada and the UK and the remaining OSC departments.

As explained in the Introduction, individuals working in each of the two geographical areas in 2007 can be partitioned into three groups: brain circulation, brain drain, and stayers (Panel C in Table 2). Note that brain circulation is a very small contingent in the U.S. (0.3% of the total), but a larger one in the OSC (7.1%). Otherwise, there are more stayers than foreigners in both areas. We begin by comparing the productivity of foreigners and stayers in the two geographical areas controlling for the individuals in brain circulation (dummy variables *USbc* and *OSCbc*), as well as the type of department in which they work in 2007 (dummy variables *Top25US* and *Last27US*). Omitting demographic variables, *model 2* is the following:

$$Log\,Q = \alpha_0 + \beta_1 FrgUS + \beta_2 StayUS + \beta_3 FrgOSC + \delta_1 Top25US + \delta_2 Last27US + \delta_3 USbc + \delta_4 OSCbc + \varepsilon, \quad (2)$$

where the constant includes OSC stayers. To test for the existence of department effects we specify the following hypothesis:

Between *Top25US* and *Last27US*, H_0: $\delta_1 - \delta_2 = 0$;

Between foreigners in *Last27US* and *OSC*, H_0: $(\delta_2 + \beta_1) - \beta_3 = 0$;

Between stayers in *Last27US* and *OSC*, H_0: $\delta_2 + \beta_2 = 0$.

[11] In particular, the last 27 U.S. departments include nine institutions that range from positions 32 to the 44 in the Econphd ranking, and 18 departments ranging from positions 51 to the 78 position, while the 29 OSC departments include four departments in the range 12 to 24, seven departments ranging from positions 30 to the 45, and 18 departments ranging from positions 46 to the 81 (Table A in Appendix I).

In turn, the key comparisons between the productivity of foreigners and stayers requires testing whether $\beta_1 - \beta_2 = 0$ in the U.S., and whether $\beta_3 = 0$ in the OSC.

Together with demographic variables, we include a set of dummy variables that capture the progression of economists' through their undergrtaduate and gradate education to the first part of their academic career. Specifically, these variables capture the university where individuals obtain their B.A., their Ph.D., or where they held their first job. The distribution of the 2,530 economists in the sample according to these career variables is in Panels D, E, and F in Table 2. In each case, we distinguish between different types of U.S. universities, universities in the European Union before the 2004 accession (EU hereafter), and universities from the Rest of the World (RW hereafter).

The following three comments are in order. Firstly, U.S. graduate schools are very attractive for this set of highly productive economists. In particular, approximately 44% of them earned their Ph.D. at the ten top U.S. schools. Secondly, because some individuals returned home after earning their Ph.D., those holding a first job in the U.S. are almost 12 percentage points lower than those graduating there. Thirdly, after a re-shuffling at the next stage, the number of people working in 2007 in the U.S. or in the European OSC increases somewhat, while the number of people working in the non-European OSC decreases. The end result is that only 38.7% of the sample is born in the U.S., but 62.0% end up working there in 2007 –a strong funneling effect towards the U.S. (see Albarrán *et al.*, 2014a, for further details).

Regression results for model 2 are in the left-hand panel of Table 4.[12] The following five points should be noted. Firstly, because all *USbc* work in *Top25US*, the coefficient δ_3 cannot be identified. Secondly, among control variables all demographic variables are significant. Age and cohort effects (column 1 in Table B.1 in Appendix I) are very similar to those analyzed in Table 3. On the other hand, only three of the other control variables are significant: individuals having earned a Ph.D. in Harvard or MIT or the RW, or having

[12] All regressions in the paper include clustered standard errors by the university where each individual works in 2007.

had a first job in any of the ten top U.S. universities have a significantly greater productivity than the corresponding reference group. The inclusion of the 29 non-demographic dummy variables increases the adjusted R^2 from 0.436 to 0.549. Thirdly, as expected, the difference $\delta_1 - \delta_2 = 0.6350$ is statistically significant (p-value = 0.000), indicating the existence of strong department effects in the U.S. What about department effects between *Last27US* and *OSC*? We find that the expressions $(\delta_2 + \beta_1) - \beta_3 = 0.1627$ and $\delta_2 + \beta_2 = 0.0717$ are not significantly different from zero (p-values 0.119 and 0.749). This indicates that the productivity of economists in the last 27 U.S. departments and the 29 OSC departments is indistinguishable. Given the overlapping of the department rankings in the two groups (see note 7), this is not a surprising result. Finally, the difference $\beta_1 - \beta_2 = 0.2910$ (p-value = 0.117) and the coefficient β_3 (t-value = 1.67) are not significantly different from zero, indicating that foreigners and stayers in the two geographical areas appear to be equally productive.

Table 4 around here

Foreigners versus stayers: final specification

The existence of department effects in the U.S. requires discussing whether higher performing universities contribute to the productivity of individual researchers and/or whether they simply attract more productive individuals. As indicated in the Introduction, our data do not allow us to address this issue. However, the results on the existence of spillover effects are clearly negative (Han Kim *et al.*, 2009, Azoulay *et al.*, 2010, Waldinger, 2012, Borjas & Doran, 2014, and Dubois *et al.*, 2014). In particular, in their important contribution to the decline of spillover effects in the top 25 U.S. university economics and finance departments over the 1970-2001 period, Han Kin *et al.* (2009) conclude that the loss of spillover effects

among elite universities is due to advances in communication technology.[13] Naturally, the decline of spillover effects is compatible with the permanence of department effects. As Han Kin *et al.* (2009) indicate, "*The difference in average individual productivity between the top 25 universities and the others has increased, not decreased, in the last three decades. Elite universities seem to attract and retain the most productive researchers, even though these universities do not make their faculty more productive*" (p. 355). This is, of course, what we find in our dataset: highly productive economists tend to come together in institutions of high productivity and prestige in a hierarchically ordered manner. Han Kim *et al.* (2009) argue that, on the supply side, top researchers agglomerate in institutions with prestigious undergraduate programs and in departments with high past research reputations. Such agglomeration could be due to the utility and the prestige of co-location with other creative minds. This, together with the role of meritocratic criteria and a reasonable degree of ability in hiring and promoting decisions on the demand side in a highly competitive market, help account for the existence of a clear hierarchical department structure, such as the one revealed in the Econphd department ranking and the two types of U.S. departments distinguished so far.

In this context, it seems convenient to compare the productivity of migrants and stayers within the top 25 and the last 27 U.S. departments. Omitting control variables, *model 3* becomes:

$$Log\,Q = \alpha_0 + \beta_1 FrgTop25US + \beta_2 StyTop25US + \beta_3 FrgLast27US + \beta_4 StyLast27US + \beta_5 FrgOSC$$

$$+ \delta_1 USbc + \delta_2 OSCbc + \varepsilon, \qquad (3)$$

where the constant includes OSC stayers. It should be noted that the proportion of migrants in the three department categories are the following: 42.8% in the top U.S. departments, 38.7% in the bottom U.S. departments, and 38.5% in the OSC. Regression results for model 3 are in the middle panel in Table 4. Key productivity comparisons between migrants and stayers in the three department categories requires testing

[13] It should be noted that the list of 25 departments in Han Kim *et al.* (2009) includes our first 15 U.S. departments. Together with the University of British Columbia, located in Canada, three other of their departments appear between positions 16 to 20 in our U.S. ranking, while the remaining six appear in the positions 26, 28, 30, 34, 43, and 46 of that ranking.

whether $\beta_1 - \beta_2 = 0$, $\beta_3 - \beta_4 = 0$, and $\beta_5 = 0$, respectively. Test results –presented in column 1 in Table 5– are as follows. Firstly, in the last 27 U.S. departments β_4 is not significantly different from zero, and foreigners are more productive than stayers. Secondly, the situation is the opposite in the top 25 U.S. departments and the OSC.

Table 5 around here

However, as observed in columns 3 and 4 in Table 6, the proportion of young and older people in the three department categories is very different for migrants and stayers. Thus, it seems essential to incorporate vintage effects in model 3.[14] This is what we do in what we call the *final specification*, whose results for the total sample appear in the right-hand panel in Table 4. The following three points should be noted.

Table 6 around here

Firstly, among control variables all demographic variables are significant. However, in the presence of interactions between the variable *Young* and foreigners and stayers in all department categories, we must differentiate between cohort effects for young foreigners and young stayers in each department category (age and cohort effects are in column 2 in Table B.2 in Appendix I). Age effects are of the same order of magnitude as we have found in previous specifications. As expected, cohort effects for both foreigners and stayers are greater in the top 25 U.S. departments than in the last two bottom department categories. Cohort effects are greater for foreigners than for stayers in each department category. On the other hand, the only significant variables among the other control variables are the same three we have found in previous specifications. The adjusted R^2 in the final specification is 0.551.

Secondly, as observed in the right-hand panel in Table 4, 10 of the 13 variables describing the two cohorts of movers and stayers in the three department categories are significant (for a discussion of the

[14] We thank a referee for pointing this out.

productivity of movers and stayers among U.S. and OSC nationals, see our companion paper Albarrán *et al.*, 2014b). For our purposes, the following result should be emphasized:

• The productivity of both young and older stayers in the last 27 U.S. departments is indistinguishable from the productivity of the reference group, namely OSC older stayers.

Thirdly, test results concerning the six productivity comparisons between foreigners and stayers are as follows (column 2 in Table 5):

• In the top U.S. category, only older migrants are more productive than stayers.

• In the bottom U.S. category, both young and older migrants are more productive than stayers.

• In the OSC, the productivity of both cohorts of migrants is indistinguishable from the productivity of stayers.

III.2. Results for the elite

As indicated in the Introduction, the mixed evidence found in the literature concerning productivity comparisons between migrants and stayers in the U.S. for samples of different nature and different size suggests analyzing the question using different quality thresholds in our case. Consequently, we study whether the results in the total sample are maintained in the elite consisting of 833 economists with above average productivity.

Descriptive statistics are in the right-hand side of Table 2. Four points should be noted. Firstly, the proportion of young people for all cohort definitions decreases: relative to the total sample, old people are overrepresented in the elite. Secondly, relative to the total sample the proportion of U.S. stayers (mostly in the top 25 U.S. departments) increases, whereas the proportion of migrants in the U.S. remains constant. Thirdly, the proportion of people of all sorts working in 2007 the OSC –brain circulation, migrants and

stayers– decreases. Finally, the proportions of migrants in the three department categories are the following: 35.0% in the top U.S. departments, 40.6% in the bottom U.S. departments, and 29.4% in the OSC.

Complete regression results for the elite appear in the last two columns in Table 4. Among demographic variables, the following two points should be noted. Firstly, among age and cohort variables only *Age* is significant. In any case, the size of age effects in the elite is much smaller than in the total sample. Two factors might help explain this pattern: (i) a stronger taste for "puzzle solving", peer recognition, and monetary rewards for top researchers produces a flattening of the productivity profile (Levin and Stephan, 1991), and (ii) institutional explanatory variables –such as research funding and promotion policies– may operate differentially across the distribution of scientific performance favoring those on the top (Kelchtermans and Veugelers, 2011).[15] Secondly, the productivity of females –representing 5.4% of the elite– is still smaller than the productivity of males, but the gender effect is considerably smaller than in the total sample: 15.4% rather than 57.9%. This is in line with the results in Kelchtermans and Veugelers (2012): although females are significantly less likely to reach top performance first, once they manage to do that the gender bias is considerably reduced. On the other hand, among the other control variables only earning a Ph.D. in any of the 50 schools different from Harvard and MIT has a negative significant effect relative to earning it in the EU. The adjusted R^2 is 0.317, versus 0.551 in the total sample.

Intuitively, increasing the quality threshold and reducing the sample size, would tend to make elite members more homogeneous among each other in each of the three department categories we have been studying. As a matter of fact, our extension of the Hunter *et al.* (2009) model in Appendix II establishes that the higher the quality threshold considered, the closer the average productivity of foreigners and stayers is expected to be. As can be observed in column 3 in Table 5, this is exactly what happens for all comparisons where foreigners were more productive than stayers in the total sample.

IV. ROBUSTNESS

[15] For a discussion of heterogeneity in patterns of productivity over time, see Carrasco & Ruiz-Castillo (2014).

IV.1. The treatment of the elite

Following a referee's suggestion, we have explored the elite's role using quantile regressions. Our results indicate that the disappearance of the productivity differences between migrants and stayers in the U.S. is reached at the 95th percentile (regression results for the total sample are in Table C in Appendix I, whereas *p*-values for productivity comparisons are in column 4 in Table 5). Of course, quantile regressions use all data in the total sample but apply different weights at observations below and above a given percentile, whereas results for the elite are obtained using exclusively its 833 observations. Recall that the elite includes individuals with above average productivity beyond the 67th percentile of the Q distribution. Taking into account that the elite productivity distribution is as highly skewed as the total sample distribution, and the mean is located at the 65th percentile, OLS results for the elite are at, approximately, the 88.5th percentile of the original distribution. Thus, using quantile regressions for the total sample or OLS for the elite leads to the same conclusions.

IV.2. The partition of departments

So far, we have distinguished between two department categories in the U.S.: the top 25 and the last 27 departments. However, in view of the possible existence of department effects within the first category, it seems interesting to explore a partition including the top ten and the next 15 U.S. departments. On the other hand, Canada and the UK are English-speaking countries whose higher education systems are closer in governance to the U.S. system than to the systems in the other countries with at least one department in the sample (the Netherlands, Spain, Israel, Sweden, France, Germany, Belgium, Denmark and China). Therefore, it seems interesting to explore a partition including the eight UK departments and the four Canadian departments in one category, and the remaining 17 departments in the OSC in another. Surprisingly enough, in the total sample the proportion of young and older foreigners in Canada and the UK is considerably greater than in the other four department categories (descriptive statistics for movers and stayers in the two cohorts are in Table D in Appendix I).

Regression results for the key variables for the total sample and the elite including this partition into five department categories are in Table E in Appendix I (complete results are available upon request). We observe that, as expected, there are strong department effects: for migrants and stayers in both cohorts the top ten, the next 15, the last 27 U.S. departments, and the other OSC are hierarchically ordered. Moreover, the productivity of economists in Canada and the UK is indistinguishable from the productivity of those in the last 27 U.S. departments.

Results and *p*-values concerning productivity comparisons between migrants and stayers are in Panel B in Table 5. Three points should be noted. Firstly, the main novelty is that the productivity difference between older migrants and older stayers in the top 25 U.S. departments in the previous partition is seen to be essentially due to the situation in the top 10 U.S. departments. Secondly, it is important to emphasize that, as before, all significant productivity differences in the U.S. in the total sample vanish when we move to the elite. This is in spite of the fact that the proportion of young and older foreigners in the bottom U.S. departments in the elite is considerably above average. Thirdly, there are two exceptions to the similarity between foreigners and stayers in the elite. The first one is among the old in Canada and the UK, where there is an above average proportion of foreigners (Table D in Appendix I). The second exception is among the small group of 27 young economists in other OSC.

Given these results, for the sake of simplicity we continue the analysis restricting the attention to the partition of the 81 departments into only three categories.

IV.3. The definition of the two cohorts

Based on the analysis in Section III.1, so far we have considered young individuals with $Age \leq 20$. Next, we must study the robustness of our results to alternative definitions, namely, when $Age \leq 15$ and $Age \leq 24$ (key descriptive statistics for all cohorts are in Table 6). Regression results for the key variables for the total sample and the elite for the two new cohort definitions are in Table F in Appendix I (complete results are available upon request). Age, cohort, and gender effects in the total sample are in columns 1 and 3 in

Table B.2 in Appendix I. Two points should be noted. Firstly, as far as demographic variables are concerned, age and gender effects are very similar for the three cohort definitions. When *Age* ≤ 15 and *Age* ≤ 20, the pattern of cohort effects are also very similar. The only difference is that the size of the effects is slightly greater when *Age* ≤ 15 than when *Age* ≤ 20. On the other hand, as we saw in model 1 being young becomes negative for the largest subset of young people in the third specification (Table 3). Nevertheless, apart from the sign, the productivity gap between young and older people increases with experience in all cases. Secondly, the only significant variables among the other control variables in the total sample under the two new cohort definitions are the same three we have found when *Age* ≤ 20. Finally, the adjusted R^2 in the total sample and the elite is of the same order of magnitude for the three cohort definitions.

As far as the key productivity comparisons, *p*-values are in Panel A in Table 7. Three points should be noted. Firstly, in the last 27 U.S. departments the pattern is the same for all cohort definitions: both young and older migrants are more productive than stayers in the total sample, but productivity differences vanish in the elite.

Table 7 around here

Secondly, as the age below which individuals are considered young increases, the proportion of older people in the total sample necessarily decreases. But this decrease is more pronounced among migrants in all department categories (Table 6). In particular, the small percentage of older migrants in the top 25 U.S. departments is very productive. Thus, when *Age* ≤ 20 and *Age* ≤ 24 foreigners are more productive than stayers in this category.[16] However, when this contingent is mixed up with individuals between 45 and 50 years of age, the difference between the regression coefficients of older migrants and stayers in the top 25 U.S. departments –equal to 0.2936 (Table E in Appendix I)– is no longer significant (*p*-value = 0.127 in Table 7).

[16] Specifically, when *Age* ≤ 24 the difference between the regression coefficients of older migrants and stayers in the top 25 U.S. departments is equal to 0.4896 (Table E in Appendix I) and the *p*-value is 0.016 (Table 7), while when *Age* ≤ 20 this difference is 0.3379 (Table 4) and the *p*-value is 0.086 (Table 6).

Thirdly, the situation among older people in the OSC is exactly the opposite: as the size of the young cohort increases, the *t*-value of older foreigners in the OSC decreases from 2.0 to 1.65 and 0.6. The superiority of older migrants over older stayers in the OSC when *Age* ≤ 15 is the only productivity difference that remains in the elite.

We conclude that the differences in the results for the three cohort definitions are minor. Consequently, although these differences should be taken into account in the discussion Section, there are no reasons to depart from our preferred specification where *Young* = 1 if *Age* ≤ 20.

IV.4. The measurement of individual productivity

So far, we have used index *Q* as our productivity measure. In this Subsection we explore the robustness of our results when we use index *Q'*, characterized by a less elitist weighting scheme of our four journal classes, and index *P*, namely, the unweighted number of publications of all sorts. Regression results for the key variables for the total sample and the elite are in Table G in Appendix I (complete results are available upon request), while *p*-values for productivity comparisons are in Panel B in Table 7.

Results concerning productivity comparisons between foreigners and stayers under index *Q'* coincide with those obtained under index *Q*. However, using the unweighted number of publications breaks up the unanimous agreement concerning the superiority of foreigners over stayers in the last 27 U.S. departments in the total sample: young foreigners and stayers are now indistinguishable. Moreover, contrary also to all previous results, young migrants are more productive the young stayers in the OSC in the elite.

We conclude that, as long as we recognize the merit of publishing in more prestigious journal classes, our results are robust to different weighting schemes.

V. DISCUSSION AND CONCLUSIONS

V.1. Summary and interpretation of results

Generally, individual productivity is a variable difficult to measure in all sectors. However, the reward structure of science around the priority of discovery provides a powerful incentive for scientists in all

disciplines to publish the results of their research. The fact that publications, as well as their impact through citations, are observable facilitates the measurement of an important aspect of scientific productivity. In this paper, we have measured the individual productivity of a set of highly productive economists in terms of a quality index that weights the number of publications from the beginning of everyone's academic career up to 2007 in four equivalent journal classes.

Individual productivity distributions in all scientific fields are highly skewed regardless of the productivity measure and the size of the population studied. Accounting for such large differences for highly productive economists is the thread that runs throughout the paper. We have information on three types of variables: (i) age and gender; (ii) dummy variables capturing the progression of each individual career from college to graduate school, the first job, and the current job in 2007, and (iii) dummy variables capturing whether each individual is a mover –brain circulation or brain drain– or a stayer. For the total sample consisting of 2,530 economists, demographic variables account for 43.6% of the variance. The remaining explanatory variables raise this figure up to 55.1%.

The paper has focused on productivity comparisons between migrants and stayers in 52 U.S. departments and 29 departments in what we have called the OSC, consisting of eleven countries with at least one department in the sample. Our preferred specification includes:

- A quality index that weights very heavily publications in the best journals.
- A partition of the population into two cohorts, where young people are less than 50 years old in 2007.
- A partition of the top 81 departments in the world in 2004 into three categories: the top 25 U.S. departments, the bottom 27 U.S. departments, and the 29 OSC departments.
- An elite consisting of researchers with above average productivity.

As in Hunter *et al.* (2009), in the absence of information on the location decision we can only present correlations describing stylized facts whose explanation requires further research. The main findings –which

are robust to the treatment of the elite, a finer partition into five department categories, different cohort definitions, and a less elitist quality index– are the following four.

1. In a world of decreasing transportation, communication, and moving costs of all sorts we should expect the convergence between the average productivity of foreigners and stayers (Hunter *et al.*, 2009). This is what we find in the total sample for the young people in the top 25 U.S departments (representing 18.7% of the population), and in both cohorts in the OSC (representing 31.0% of the total). However, this is not the case in the following two groups.

2. Older migrants are more productive than stayers in the top 25 U.S. departments (representing 16.4% of the total). Two qualifications should be noted. Firstly, migrants between 45 and 50 years of age exhibit a worse performance relative to stayers of that age. Consequently, the superiority of old migrants vanishes when we define young people as those with $Age \leq 15$ (Section IV.3). Secondly, the superiority of older migrants takes place in the top 10 U.S. departments (Section IV.2). Therefore, the key finding is that foreigners are more productive than stayers among people older than 50 in the top ten U.S. departments (representing 7.7% of the total).

3. Perhaps the most remarkable finding of the paper is that the productivity of U.S. stayers is much lower in the bottom than in the top U.S. departments. As a matter of fact, the productivity of stayers in the last 27 U.S. departments is indistinguishable from the productivity of stayers in the OSC. Instead, the productivity of migrants is hierarchically ordered in the top 25 U.S. departments, the last 27 U.S. departments, and the 29 OSC departments. Consequently, the standing of the bottom U.S. departments is maintained thanks to the productivity of its foreign faculty. More importantly for our purposes, the productivity of migrants is greater than the productivity of stayers in both cohorts in the last 27 U.S. departments (representing 26.5% of the total).

How should we interpret the superiority of migrants over stayers in some groups (i.e. old people in the top ten U.S. departments, and both cohorts in the bottom U.S. departments) in the total sample? One

possibility is that migration *per se* is a cause of superior performance, in which case there are positive externalities to be gained by promoting mobile scientists to work with domestic scientists. As pointed out by Franzoni *et al.* (2014), in this case migration is not a zero-sum game in the sense that the benefits that accrue to the destination country do not necessarily come at the expense of the sending country.

An alternative interpretation is that the talent distributions under comparison are not the same. This is the type of explanation we provisionally favor. Consider first the situation in the top 25 U.S. departments. In the context of the Hunter *et al.* (2009) model, the superiority of migrants simply means that –according to the productivity measures used in this paper– some of the best older economists in the world happen to be foreigners that have been attracted by these prestigious U.S. departments. On the other hand, a possible explanation of the situation in the bottom U.S. departments is the following. U.S. nationals have to balance the attraction and costs of an academic career with the opportunities that the U.S. economy offers to highly skilled economists outside academia. Judging from their relatively weak performance, those who choose an academic life at the bottom of the scale are considerably less productive and/or less motivated than those who are able to work at the top 25 departments. Instead, foreigners in the last 27 U.S. departments appear to find good reasons to pursue an academic career in the U.S., and strive to maintain a good performance just below what comparable migrants exhibit at the top 25 U.S. departments, and essentially above what foreigners exhibit in the OSC (*p*-values for the young and the old in the last comparison are equal to 0.123 and 0.055).

4. Our last finding is that, in agreement with our extension of the Hunter *et al.* (2009) model, as soon as we restrict attention to an elite consisting of economists with above average productivity all productivity differences between migrants and stayers in the U.S. vanish.

V.2. Policy considerations

Regardless of interpretation, the superior *ex post* migrants' performance in some groups and the indistinguishable performance between foreigners and stayers in the remaining groups would tend to

confirm the validity of policies aimed at facilitating increased brain exchange across countries (Franzoni *et al.*, 2014). We may add that, as long as the concentration of talent in the U.S. results from the working of a highly competitive market worldwide, efficiency is well served from a global point of view. Furthermore, we should take into account that migrants decide where to live in a voluntary way. However, there are two objections to this view.

Firstly, a number of contributions –written from a European perspective– explain this situation in terms of differences in resources and university governance on both sides of the Atlantic (Ali *et al.*, 2007, Bauwens *et al.*, 2008, Aghion *et al.*, 2008, Veugelers & Van der Ploeg, 2008, Drèze and Estevan, 2009, and Section 5.2.1 in Docquier and Rapoport, 2012). From this perspective, it might be argued that that the degree of concentration of the best talent in the U.S. constitutes only a second best. Better governance and some additional resources for research institutions in the EU and the RW may give rise to an improved global situation with the highly productive less concentrated in the U.S.

Secondly, other qualified economists question whether the concentration of the best talent working and/or studying in a few U.S. universities has gone too far. On one hand, Jacques Drèze states: "*It is thought provoking that worldwide economic research is being pursued under the leadership of a couple hundred university professors trained and employed by a handful of U.S. departments.*" (Drèze and Estevan, 2007, p. 286). On the other hand, Oswald (2007, p.2) has pointed out that great discoveries often come from unconventional ways of thinking. "*This makes me believe that dropping so many of Planet Earth's scientists into the same American part of the globe may make them worryingly homogeneous. Such intellectual homogeneity could, in the long run, be bad for scientific knowledge and thus for human welfare on our planet.*"

We should close this discussion indicating that, needless to say, immigration/emigration and other policy recommendations requires studying the results from more representative samples, including the high-skilled working outside the academic sector, as well as the low-skilled migrants. This should incorporate the recent literature on immigration emphasizing different channels through which sending countries may

benefit from international mobility in a context of increasing globalization. However, progressing in these directions is beyond the scope of this paper.[17]

V.3. Contributions to the literature

Our contributions to the literature can be summarized as follows.

1. Given the importance of department effects, comparisons between foreigners and stayers must be done within each subgroup of a relevant partition into top and bottom departments. Following this practice, we have been able to isolate the superiority of migrants over stayers among the older individuals in the top ten and in the two cohorts in the bottom U.S. departments in the total sample.

2. Confronting foreigners and stayers in a relatively large sample of highly productive scientists or in a small sample of elite scientists in the upper tail of the productivity distribution are different matters. In our case, we have found that all productivity differences between the two groups in the U.S. in the total sample disappear in an elite consisting of economists with above average productivity. Note also that this distinction makes compatible apparently divergent results in the literature for datasets of scientists of very different size and composition.

Whether the situation is different in top and bottom institutions, and whether the differences –if any– in larger samples disappear in elite subsets are interesting topics for further research in other scientific disciplines. Similarly, it would be interesting to know whether the high proportion of foreigners and their higher productivity relative to stayers found in the last 27 U.S. economics departments are maintained for other, less productive U.S. institutions.

Under the limitations of our data, we have only offered some provisional interpretations of our results. Rather than a positive migration externality, we have suggested that the superiority of older migrants in the top U.S. departments might be simply due to a difference in the upper tail of the productivity distributions of people born outside and inside the U.S. Similarly, the superiority of migrants in the bottom

[17] For a discussion of possible global and national effects of high-skilled international migration for sending and receiving countries, see Regets (2001), Commander *et al.* (2003), Ellerman (2006), and Gibson and McKenzie (2012).

U.S. departments might be due to a switch away from the academic sector by a subset of economists more attracted by opportunities in other sectors of the U.S. economy than by the benefits associated to academic work outside the very top U.S. departments. Naturally, these conjectures call for further research.

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APPENDIX I. STATISTICAL MATERIAL

Table A. Publications in journals of class A, B, C and D, and quality indices for 2,705 faculty members at 81 economics departments in 2007

		Number of scholars		Number of publications						
		Total	Without any publication	A	B	C	D	Total	Quality Index, Q	Quality Index, Q'
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	81 TOP ECONOMICS DEPARTMENTS:									
	Ordered according to the Econphd (2004) ranking	**2,705**	**175**	**9,595**	**20,261**	**10,260**	**28,255**	**68,371**	**777,530**	**474,065**
	U.S. DEPARTMENTS									
	Top ten									
1	Harvard University	55	0	842	914	299	862	2,917	50,046	28,337
2	University of Chicago	30	1	291	294	110	254	949	16,964	9,564
3	MIT	40	2	602	593	208	948	2,351	35,171	19,958
4	U. of California, Berkley	58	1	463	660	286	754	2,163	30,890	18,044
5	Princeton University	54	4	509	642	172	826	2,149	31,848	18,286
6	Stanford University	42	4	314	316	100	318	1,048	18,218	10,258
7	Northwestern University	35	4	230	307	87	279	903	14,606	8,384
8	University of Pennsylvania	30	1	215	358	89	162	824	14,666	8,487
9	Yale University	42	6	350	518	145	706	1,719	23,346	13,611
10	New York University	44	1	348	529	129	524	1,530	23,153	13,419
	Next 15									
11	U. of California, LA	45	2	213	250	182	379	1,024	13,741	8,049
13	Columbia University	45	0	388	529	209	565	1,691	25,274	14,660
14	U. of Wisconsin, Madison	30	5	86	238	74	154	552	7,608	4,624
15	Cornell University	32	1	156	393	182	472	1,203	13,699	8,432
16	University of Michigan	54	6	216	348	145	443	1,152	15,173	8,968
17	University of Maryland	39	2	145	257	229	304	935	11,333	6,919
19	U. of Texas, Austin	33	2	114	243	120	328	805	9,253	5,638
21	U. of Cal., San Diego	40	3	180	394	103	318	995	14,046	8,373
22	University of Rochester	19	3	57	101	51	100	309	4,201	2,505
23	Ohio State University	39	2	139	292	170	344	945	11,304	6,894
25	U. of Illinois, Urbana	27	2	45	176	91	209	521	5,195	3,324
26	Boston University	38	4	157	240	129	189	715	10,843	6,374
27	Brown University	28	3	125	184	150	128	587	8,788	5,218
28	U. California, Davis	31	1	55	191	158	240	644	6,253	4,030
29	University of Minnesota	26	3	126	191	50	101	468	8,306	4,781
	Last 27									
32	U. of Southern California	31	4	87	285	160	652	1,184	9,367	6,042
33	Michigan State U.	44	1	101	328	182	340	951	10,392	6,550
35	Duke University	43	0	148	296	174	554	1,172	11,958	7,344
38	PA State University	24	2	65	154	84	191	494	5,605	3,451
40	Carnegie Mellon U.	23	1	57	103	31	74	265	4,085	2,399
41	U. of North Carolina	24	2	22	144	69	240	475	3,694	2,465
42	Boston College	26	1	69	223	114	222	628	7,011	4,402
43	CA Institute of Technology	17	0	88	162	74	136	460	6,530	3,886

44	Texas A and M	25	1	50	161	103	183	497	5,216	3,308
49	University of Indiana	26	2	27	140	111	159	437	4,005	2,654
51	Johns Hopkins	14	0	80	171	54	104	409	6,193	3,684
52	Rutgers University	33	1	41	153	157	336	687	5,213	3,471
53	University of Virginia	32	4	67	157	126	142	492	5,933	3,682
54	Vanderbilt University	34	1	95	275	227	529	1,126	9,816	6,314
55	Georgetown University	25	2	45	175	63	73	356	4,876	3,038
56	Arizona State University	28	3	59	244	171	344	818	7,390	4,819
57	University of Arizona	25	6	39	87	72	103	301	3,400	2,113
58	Dartmouth College	29	2	45	136	123	234	538	4,812	3,109
60	University of Washington	25	1	82	271	140	181	674	8,366	5,231
62	Iowa State University	44	0	34	218	362	809	1,423	7,611	5,479
63	Washington U., St Louis	30	1	133	246	177	220	776	10,292	6,225
67	Purdue University	20	5	29	87	86	184	386	3,165	2,064
70	University of Pittsburgh	25	5	36	142	50	174	402	4,044	2,564
72	University of Iowa	18	3	31	139	53	77	300	3,720	2,352
75	Rice University	19	1	63	151	91	206	511	5,537	3,431
77	U. of California, Irvine	25	3	23	143	136	238	540	4,119	2,808
78	University of Florida	18	1	30	109	93	269	501	3,662	2,424
	NON-U.S. DEPARTMENTS IN OTHER SAMPLE COUNTRIES									
	European Union									
12	London Sch. of Economics	55	4	189	421	116	441	1,167	15,012	9,011
18	Toulouse University	78	0	126	421	203	830	1,580	13,403	8,575
24	Tilburg University	54	2	39	377	301	1,238	1,955	10,259	7,293
31	Oxford University	44	1	153	395	177	634	1,359	13,741	8,529
34	University of Warwick	44	2	88	393	204	375	1,060	11,014	7,085
37	University of Amsterdam	39	1	19	202	125	333	679	4,873	3,358
39	Cambridge University	31	1	70	207	73	342	692	6,685	4,177
45	European Institute	12	1	23	152	49	161	385	3,655	2,386
46	U. Carlos III, Spain	56	5	15	191	81	377	664	4,328	2,992
47	Univ. College London	35	2	120	292	103	376	891	10,174	6,211
48	University of Essex	30	2	30	148	73	95	346	3,953	2,540
59	Stockholm University	18	0	23	86	51	216	376	2,732	1,791
65	University of York	42	1	24	139	87	398	648	3,965	2,703
66	U. Pompeu Fabra	39	3	48	143	54	428	673	4,817	3,088
68	University of Nottingham	47	0	30	305	211	847	1,393	7,888	5,552
71	Stockholm School of Ecs.	15	1	16	86	68	332	502	2,670	1,852
73	Erasmus University	22	1	15	149	95	410	669	3,815	2,675
74	University of Copenhagen	46	4	10	179	71	317	577	3,828	2,662
76	Catholic Univ. of Louvain	40	0	24	221	140	678	1,063	5,793	4,068
79	U. Autónoma, Barcelona	37	4	15	98	68	416	597	2,894	2,036
80	Free Univ. of Amsterdam	23	2	11	115	55	183	364	2,678	1,828
81	University of Bonn	26	5	56	147	104	517	824	5,586	3,627
	Other: Canada, China, and Israel									
20	Univ. of British Columbia	30	3	73	188	110	160	531	6,560	4,050
60	Queen's University	26	3	42	213	120	143	518	5,738	3,713
36	University of Tel Aviv	16	1	58	205	70	122	455	5,937	3,682

50	University of Montreal	23	1	18	160	122	155	455	4,007	2,725
51	University of Toronto	53	8	99	255	190	402	946	9,327	5,882
54	Hebrew University	26	0	133	219	157	408	917	9,955	6,043
59	Hong Kong University	15	1	16	97	31	40	184	2,321	1,485

Table B.1. Age and cohort effects when *Young* = 1 if *Age* ≤20 in models 2 and 3 for the total sample

	MODEL 2 (1)	MODEL 3 (2)
• **Age effects when:**		
***Age* = 5**	0.2789	0.3319
***Age* = 10**	0.1709	0.2781
***Age* = 30**	0.0498	0.0524
• **Cohort effects when:**		
***Age* = 5**	0.544	0.5356
***Age* = 10**	0.996	0.9849

Table B.2. Age, cohort and gender effects the final specification for the total sample when *Young* = 1 if:

	Age ≤15 (1)	*Age* ≤20 (2)	*Age* ≤24 (3)
• **Age effects when:**			
***Age* = 5**	0.2656	0.2773	0.3178
***Age* = 10**	0.1764	0.1704	0.2707
***Age* = 30**	0.0538	0.0499	0.0029
• **Cohort effects for foreigners**			
Top 25 U.S. departments			
***Age* = 5**	1.7491	1.5519	-1.4101
***Age* = 10**	2.1117	2.0001	-0.1226
Last 27 U.S. departments			
***Age* = 5**	1.2235	0.7708	-1.6805
***Age* = 10**	1.5860	1.2189	-0.3930
29 OSC departments			
***Age* = 5**	1.0255	0.8469	-2.0838
***Age* = 10**	1.3880	1.2950	-0.7421
• **Cohort effects for stayers**			
Top 25 U.S. departments			
***Age* = 5**	1.6541	1.4405	-1.5365
***Age* = 10**	2.0142	1.8886	-0.2490
Last 27 U.S. departments			
***Age* = 5**	0.7942	0.2228	-2.2845
***Age* = 10**	1.1568	0.6709	-0.9970
29 OSC departments			
***Age* = 5**	0.8853	0.6942	-2.2870
***Age* = 10**	1.2479	1.1424	-1.0004
• **Gender effects**	0.5575	0.5550	0.5602

Table C. Results for the final specification (productivity measure = *Q* index, *Young* = 1 if *Age* ≤20). Quantile regression results for the 95th percentile in the total sample

Dependent variable: Log *Q*

I. KEY EXPLANATORY VARIABLES

CURRENT JOB = U.S.	**Coeff.**	***t*-value**
1. *Brain circulation*	0.8694	1.6
Top 25, Young		
2. *Foreigners*	0.7650	2.8*
3. *Stayers*	0.5734	1.7
Top 25, Old		
4. *Foreigners*	0.6501	3.5*
5. *Stayers*	0.4337	1.86
Last 27, Young		
6. *Foreigners*	0.2298	0.8
7. *Stayers*	0.0167	0.05
Last27, Old		
8. *Foreigners*	0.2323	1.1
9. *Stayers*	0.0874	0.3
CURRENT JOB = OSC		
10. *Brain circulation*	0.0199	0.1
Young		
11. *Foreigners*	0.1073	0.4
12. *Stayers*	-0.0310	-0.1
Old		
13. *Foreigners*	0.2863	1.0
14. *Stayers* = Reference group		

II. CONTROL VARIABLES

A. Demographic variables	**Coeff.**	***t*-value**
1. *Age*	0.1329	11.7*
2. Age^2	-0.0013	-6.2*
3. *Young* x *Age*	0.1511	5.7*
4. *Young* x Age^2	-0.0060	-5.2*
5. *Young*	-0.3473	-1.3*
6. *Female*	-0.2967	-3.8*
B. University of B.A.		
U.S.		
1. *Top 10 U.S.*	0.0373	0.2
2. *Next* 15 *U.S.*	0.0047	0.02
3. *Next 27* U.S.	-0.0065	-0.03
4. *Other U.S.*	-0.0667	-0.03
Outside U.S.		
5. Reference group = *EU*		
6. *RW*	0.0352	0.2

C. University of Ph.D.		
U.S.		
1. *Harvard* & *MIT*	0.0935	0.7
2. *Other Top 10 U.S.*	-0.1980	-1.7
3. *Next* 15 *U.S.*	-0.2054	-1.7
4. *Next* 27 *U.S.*	-0.0468	-0.3
5. *Other U.S.*	-0.1381	-0.6
Outside U.S.		
6. Reference group = *EU*		
7. *RW*	0.0352	0.2
D. University of first job		
U.S.		
1. *Top 10 U.S.*	0.1927	1.7
2. *Next* 15 *U.S.*	-0.0805	-0.7
3. *Next 27* U.S.	-0.0804	-0.7
4. *Other U.S.*	-0.1606	-1.2
Outside U.S.		
5. Reference group = *EU* + Missing		
6. *RW*	-0.1142	-1.2
7. *Missing*	-0.7959	-2.1*
Constant	4.0239	20.7*
N	2,530	
Pseudo-R^2	0.370	

Table D. Descriptive statistics in the total sample and the elite. Movers & stayers for the partition into five department categories (*Young* = 1 if *Age* ≤ 20)

	Total sample		Elite	
CURRENT JOB = U.S.	**Freq.**	**%**	**Freq.**	**%**
1. *Brain circulation*	8	0.3	5	0.6
A. Top 10, *Young*				
2. *Foreigners*	124	4.9	40	4.8
3. *Stayers*	83	3.3	35	4.2
Old				
4. *Foreigners*	54	2.1	50	6.0
5. *Stayers*	141	5.6	123	14.8
B. Next 15, *Young*				
6. *Foreigners*	144	5.7	25	3.0
7. *Stayers*	123	4.9	33	4.0
Old				
8. *Foreigners*	62	2.4	45	5.4
9. *Stayers*	157	6.2	101	12.1
C. Last 27, *Young*				
10. *Foreigners*	186	7.3	30	3.6
11. *Stayers*	135	5.3	12	1.4
Old				
12. *Foreigners*	74	2.9	44	5.3
13. *Stayers*	276	10.9	96	11.5
CURRENT JOB = OSC				
D. Canada + UK				
14. *Brain circulation*	53	2.1	19	2.3
Young				
15. *Foreigners*	195	7.7	12	1.4
16. *Stayers*	66	2.6	9	1.1
Old				
17. *Foreigners*	50	2.0	27	3.2
18. *Stayers*	68	2.7	36	4.3
E. Other OSC				
19. *Brain circulation*	128	5.1	45	5.4
Young				
20. *Foreigners*	104	4.1	10	1.2
21. *Stayers*	189	7.5	17	2.0
Old				
22. *Foreigners*	22	0.9	8	1.0
23. *Stayers*	88	3.5	26	3.1
Total	**2,530**	**100.0**	**833**	**100.0**

Proportion of foreigners in the double partition by department categories and cohorts

	Total sample		Elite	
	Young	**Old**	**Young**	**Old**
A. Top 10	59.6	27.7	53.3	28.1
B. Next 15	53.9	28.3	43.1	30.8
C. Last 27	57.9	21.1	71.4	31.4
D. Canada + UK	67.9	34.5	44.4	35.5
E. Other OSC	26.9	15.2	27.0	14.8
Total	**51.3**	**25.3**	**48.9**	**29.3**

Table E. Results for the final specification (productivity measure = Q index, $Young$ = 1 if $Age \leq 20$) for the partition of the 81 departments into five classes. Total sample and elite

Dependent variable: Log Q

	TOTAL SAMPLE		ELITE	
I. KEY EXPLANATORY VARIABLES				
CURRENT JOB = U.S.	**Coeff.**	***t*-value**	**Coeff.**	***t*-value**
1. *Brain circulation*	1.4973	3.0*	0.8231	2.6*
Top 10, Young				
2. *Foreigners*	2.1255	7.1*	0.5217	4.1*
3. *Stayers*	2.0026	6.0*	0.5466	2.7*
Top 10, Old				
4. *Foreigners*	1.8711	8.1*	0.6744	6.6*
5. *Stayers*	1.4541	4.6*	0.4446	2.6*
Next 15, Young				
6. *Foreigners*	1.6468	5.7*	0.3879	2.8*
7. *Stayers*	1.5001	3.7*	0.2516	1.4
Next 15, Old				
8. *Foreigners*	1.2624	5.1*	0.3098	3.3*
9. *Stayers*	0.9294	3.0*	0.1726	1.0
Last 27, Young				
10. *Foreigners*	1.3039	4.8*	0.3146	2.5*
11. *Stayers*	0.8688	2.6*	0.2384	1.5
Last 27, Old				
12. *Foreigners*	1.0605	4.4*	0.1875	2.1*
13. *Stayers*	0.4601	1.5	0.1280	0.8
CURRENT JOB = OSC				
14. *Brain circulation, Canada + UK*	1.1364	3.8*	0.3285	2.4*
15. *Brain circulation, Other OSC*	0.9316	4.8*	0.2888	2.9*
Canada + UK, Young				
16. *Foreigners*	1.2493	4.6*	0.2693	2.3*
17. *Stayers*	1.0100	3.5*	0.3077	1.89
Canada + UK, Old				
18. *Foreigners*	0.8327	3.2*	0.1912	1.8
19. *Stayers*	0.8076	3.1*	0.0522	0.7
Other OSC, Young				
20. *Foreigners*	0.8193	3.0*	0.3139	2.3
21. *Stayers*	0.8830	3.6*	0.1050	0.8
Other OSC, Old				
22. *Foreigners*	0.2188	0.7	0.0104	0.1
23. *Stayers* = Reference group				
Constant	1.5129	7.2*	5.4195	24.3*
N	2,530		833	
Pseudo-R^2	0.567		0.357	

Table F. Results for the total sample and the elite under alternative cohort definitions (productivity index = *Q*)

	Young = 1 if:							
Dependent variable: Log *Q*	***Age* ≤ 15**				***Age* ≤ 24**			
I. KEY EXPLANATORY VARIABLES	**Total sample**		**Elite**		**Total sample**		**Elite**	
CURRENT JOB = U.S.	**Coeff.**	***t*-value**	**Coeff.**	***t*-value**	**Coeff.**	***t*-value**	**Coeff.**	***t*-value**
1. *Brain circulation*	1.0832	2.3*	0.7748	2.6*	1.2633	2.6*	0.8321	2.7*
Top 25, Young								
2. *Foreigners*	1.2281	5.2*	0.1469	0.7	1.4834	5.6*	0.4443	3.1*
3. *Stayers*	1.1321	3.9*	0.1569	0.6	1.3569	4.6*	0.3401	1.95
Top 25, Old								
4. *Foreigners*	1.0520	5.9*	0.4034	5.0*	1.1937	5.7*	0.4337	4.6*
5. *Stayers*	0.7584	3.0*	0.2717	2.0*	0.7041	2.7*	0.3342	2.4*
Last 27, Young								
6. *Foreigners*	0.7024	3.0*	0.0923	0.4	1.0129	3.9*	0.2093	1.6
7. *Stayers*	0.2732	0.9	0.0791	0.3	0.6089	2.1*	0.2160	1.3
Last 27, Old								
8. *Foreigners*	0.5640	3.2*	0.1261	1.84	0.5696	2.4*	0.1942	2.2*
9. *Stayers*	0.0998	0.4	0.1094	0.8	0.0245	0.1	0.1550	1.1
CURRENT JOB = OSC								
10. *Brain circulation*	0.3704	2.3*	0.1914	2.4*	0.6538	2.9*	0.2602	2.4*
Young								
11. *Foreigners*	0.5044	2.6*	0.0351	0.2	0.8096	3.6*	0.2033	1.5
12. *Stayers*	0.3642	1.6	-0.1021	-0.4	0.6064	2.7*	0.1234	0.8
Old								
13. *Foreigners*	0.2737	2.0*	0.1181	2.3*	0.1061	0.6	0.1560	1.84
14. *Stayers* = Reference group								
Constant	1.5321	9.0*	5.5120	21.3*	5.7092	6.9*	5.8398	10.1*
N	2,530		833		2,530		833	
Pseudo-R^2	0.549		0.317		0.556		0.317	

Table G. Results for the total sample and the elite under alternative productivity measures (*Young* = 1 if *Age* ≤ 20)

	Productivity index:							
Dependent variable: Log *Q*	***Q'***				***P***			
I. KEY EXPLANATORY VARIABLES	**Total sample**		**Elite**		**Total sample**		**Elite**	
CURRENT JOB = U.S.	**Coeff.**	***t*-value**	**Coeff.**	***t*-value**	**Coeff.**	***t*-value**	**Coeff.**	***t*-value**
1. *Brain circulation*	1.0184	2.4*	0.6640	2.1*	0.4533	1.4	0.1928	0.7
Top 25, Young								
2. *Foreigners*	1.2814	5.1*	0.3271	2.8*	0.6871	4.0*	0.1379	1.2
3. *Stayers*	1.1925	4.3*	0.2289	1.3	0.6559	3.4*	0.1470	0.7
Top 25, Old								
4. *Foreigners*	0.9925	5.5*	0.4036	4.7*	0.5061	5.3.4	0.1026	1.3
5. *Stayers*	0.6981	2.9*	0.1845	1.2	0.3550	1.90*	-0.0347	-0.2
Last 27, Young								
6. *Foreigners*	0.8470	3.4*	0.2292	2.0*	0.5178	3.0*	0.2468	1.6
7. *Stayers*	0.5240	1.88	0.1651	0.9	0.4294	2.2*	0.0560	0.3
Last 27, Old								
8. *Foreigners*	0.5859	3.1*	0.1226	1.5	0.2717	2.0*	-0.0555	-0.7
9. *Stayers*	0.0945	0.4	0.0600	0.4	-0.0342	-0.2	-0.0477	-0.3
CURRENT JOB = OSC								
10. *Brain circulation*	0.5446	2.8*	0.1897	2.0*	0.4335	2.6*	0.1232	1.3
Young								
11. *Foreigners*	0.6745	3.0*	0.2024	1.6	0.4169	2.5*	0.1486	1.1
12. *Stayers*	0.5409	2.6*	0.0700	0.7	0.4003	2.6*	-0.0158	-0.2
Old								
13. *Foreigners*	0.2422	1.6	0.1029	1.5	0.0415	0.4	-0.0591	-0.8
14. *Stayers* = Reference group								
Constant	1.6006	8.5*	5.0040	16.6*	0.4916	4.1*	3.8631	11.2*
N	2,530		843		2,530		835	
Pseudo-R^2	0.568		0.304		0.617		0.220	

APPENDIX II. THE HUNTER, OSWALD & CHARLTON (2009) MODEL

Consider a world in which scientists vary in their innate ability and productivity. Let q be an individual's productivity that is defined to lie between 0 and 1. The talent distribution is described by a density function $f(q)$. 'Highly productive' scientists have productivity greater than a minimum threshold of quality, q^*. Such scientists can choose whether or not to move to a host country, where they are assumed to perceive a percentage wage premium, p, compared to the home country. More generally, p can include a percentage non-wage premium derived from superior research facilities, and the prevalence of meritocratic practices in hiring and promotion policies in the host country that may be lacking in the home country. To help the intuition, assume that the rich country is the U.S. There is a cost of movement, c, capturing any continuing cultural and personal cost caused by living abroad.

The net utility levels of potential movers and stayers in the original country are given by a simple additive form:

$$\textit{Utility of a mover} = (1 + p)q - c$$

$$\textit{Utility of a stayer} = q.$$

An individual will choose to move if

$$(1 + p)q - c - q = pq - c > 0, \text{ or } q > c/p.$$

The average productivity of migrants is

$$M = \int_{c/p}^{1} qf(q)\mathrm{d}q / \int_{c/p}^{1} f(q)\mathrm{d}q. \quad (1)$$

Assume that scientists in the host country are characterized by the same talent density function $f(q)$. Then, the average productivity of stayers in the host country is

$$S = \int_{q^*}^{1} qf(q)\mathrm{d}q / \int_{q^*}^{1} f(q)\mathrm{d}q. \quad (2)$$

It can be shown that the difference in mean productivities,

$$M - S = D(c, p, q^*), \quad (3)$$

is an increasing function of the mobility cost c, and a decreasing function of the premium p.

If the cost of mobility and the premium are both positive, $c < p$, and c is sufficiently large, then $q^* < c/p < 1$, so that the difference D is positive and the quality of movers, on average, will exceed the quality of stayers. In other words, if it is very costly to leave one's country and the premium is sufficiently high, only absolutely outstanding scientists will find it worth their while. Consequently, migrants would be positively selected relative to stayers in the host country. However, as c declines, the difference D approaches zero, and highly productive migrants and stayers come from approximately the same section of the underlying talent distribution, so that they will have similar observed productivity levels.

The next extension is useful for our purposes. As q^* increases, q^* becomes closer to c/p, so that the difference D in expression 3 decreases. In other words, as the minimum quality threshold increases and we move from the set of highly productive scientists towards what we call the elite, elite migrants and stayers come from approximately the same section of the underlying talent distribution, so that they will have similar observed productivity levels.

Note that the Hunter *et al.* (2009) model is a simplified version of the standard income-maximizing model on the selection of immigrants (Borjas, 1987, and Section 3 in Borjas, 1999) based on the seminal contribution by Roy (1951). However, the latter emphasizes the role of earnings inequality for the selection of migrants. If the correlation coefficient of the observed component of earnings across countries is sufficiently high, and the unobserved component of earnings in the host country exhibits greater (lower) inequality than in the home country, migrants will be positively (negatively) selected from the upper tail of the home country's income distribution and will outperform the native born (will not perform well) in the host country. Differences in mean earnings at home and abroad, as well as migration costs, do affect migration probabilities but they have no effect on the direction of selection. In another application of the Roy model, Grogger and Hanson (2011) provide an integrated framework to examine the fraction of the population that emigrates, the selectivity of migrants in terms of schooling, and the sorting of migrants by schooling level across destinations.

Table 1. Characteristics of productivity distributions

A. Productivity means

Productivity index	μ_1	μ_2
Q	307.3	707.3
Q'	187.4	419.5
P	27.0	59.2

B. Skewness of productivity distributions

	% of individuals in category:			% of total productivity accounted for by category:		
	1	**2**	**3**	**1**	**2**	**3**
Q	67.1	21.4	11.5	24.2	32.2	43.6
Q'	66.7	21.2	12.1	25.4	31.3	43.3
P	67.0	22.0	11.0	27.7	32.8	39.5

Category 1 = individuals with productivity $\leq \mu_1$

Category 2 = individuals with productivity between μ_1 and μ_2

Category 3 = individuals with productivity $> \mu_2$

C. Elite sizes

Q	833
Q'	843
P	835

Table 2. Explanatory variables. Descriptive statistics

A. DEMOGRAPHIC VARIABLES	**TOTAL SAMPLE**		**ELITE**	
Mean *Age* (Standard deviation)	18.8 (12.4)		27.2 (10.4)	
Cohorts according to three definitions:				
1. % *Young*[a]	50.1%		28.7%	
2. % *Young*[b]	45.8%		13.1%	
3. % *Young*[c]	67.1%		43.9%	
% *Females*	14.0%		5.4%	
B. UNIVERSITY OF CURRENT JOB	**Frequency**	**%**	**Frequency**	**%**
1. *Top 25 U.S. departments*	896	35.4	457	54.9
2. *Last 27 U.S. departments*	674	26.6	182	21.8
3. *OSC departments**	963*	38.0	194	23.3
Total	**2,530**	**100.0**	**833**	**100.0**
C. MOVERS & STAYERS				
Current job = U.S.				
1. *Brain circulation*	8	0.3	5	0.6
2. *Foreigners, Brain drain*	644	25.5	234	28.1
3. *Stayers*	915	36.2	400	48.0
Current job = OSC				
4. *Brain circulation*	181	7.1	49	5.9
5. *Foreigners, brain drain*	371	14.7	57	6.8
6. *Stayers**	411*	16.2	88	10.6
Total	**2,530**	**100.0**	**833**	**100.0**
D. UNIVERSITY OF B.A.				
1. *Top 10 U.S.*	298	11.8	147	17.6
2. *Next 15 U.S.*	144	5.7	70	8.4
3. *Next 27 U.S.*	134	5.3	49	5.9
4. *Other U.S.*	403	15.9	153	18.4
5. *EU*[d]*	949*	37.5	222	26.6
6. *RW*[e]	602	23.8	192	23.1
Total	**2,530**	**100.0**	**833**	**100.0**
E. UNIVERSITY OF Ph.D.				
1. *Harvard & MIT*	352	13.9	178	21.4
2. *Other Top 10 U.S.*	749	29.6	273	32.8
3. *Next 15 U.S.*	416	16.4	133	16.0
4. *Next 27 U.S.*	181	7.2	58	7.0
5. *Other U.S.*	51	2.1	11	1.3
6. *EU*[d]*	681*	26.9	147	17.6
7. *RW*[e]	100	3.9	33	3.9
Total	**2,530**	**100.0**	**833**	**100.0**

F. UNIVERSITY OF FIRST JOB

1. *Top 10 U.S.*	539	21.2	291	34.9
2. *Next 15 U.S.*	369	14.5	139	16.7
3. *Next 27 U.S.*	362	14.3	99	11.9
4. *Other U.S.*	174	6.8	42	5.0
5. *EU*[d]*	682*	27.2	160	19.2
6. *RW*[e]	390	15.5	101	12.1
7. *Missing*	13	0.5	10	0.1
Total	**2,530**	**100.0**	**833**	**100.0**

[a] *Young* = Individuals with less than 20 years after earning a Ph.D. ~ less than 50 years of age

[b] *Young* = Individuals with less than 15 years after earning a Ph.D. ~ less than 45 years of age

[c] *Young* = Individuals with less than 24 years after earning a Ph.D. ~ less than 54 years of age

[d] *EU* stands for the 15 countries in the European Union before the 2004 accession

[e] *RW* stands for the Rest of the World, namely, countries outside the U.S.and the EU

Table 3. The role of demographic variables in the total sample

Model 1: $Log\,Q = \alpha_0 + \alpha_1 Age + \alpha_2 Age^2 + \alpha_3 (Age \text{ x } Young) + \alpha_4 (Age^2 \text{ x } Young) + \alpha_5 Young + \alpha_6 Female + \varepsilon$

Age effects: $(\alpha_1 + \alpha_3) + 2(\alpha_2 + \alpha_4) Age$, if $Young = 1$

$\alpha_1 + 2\,\alpha_2 Age$, if $Young = 0$

Cohort effects: $\alpha_3 Age + \alpha_4 Age^2 + \alpha_5$, if $Young = 1$

Gender effect: α_6

	***Young* = 1 if:**					
	***Age* ≤ 20**		***Age* ≤ 15**		***Age* ≤ 24**	
Variables	**Coeff.**	***t*-value**	**Coeff.**	***t*-value**	**Coeff.**	***t*-value**
Age	0.1397	10.9	0.1557	13.2	- 0.0888	- 1.8
Age^2	- 0.0014	- 5.3	- 0.0016	- 6.4	0.0015	2.4
Age x *Young*	0.2108	8.4	0.1655	10.0	0.4184	7.7
Age^2 x *Young*	- 0.0081	- 7.8	- 0.0062	- 8.5	- 0.0096	- 9.8
Young	- 0.3771	- 2.8	0.0034	0.04	- 4.5674	- 2.8
Female	- 0.5794	- 6.8	- 0.5819	- 6.9	- 0.5822	- 6.8
Constant	2.6462	13.9	2.3502	13.9	6.873	7.4
N	2,530		2,530		2,530	
R^2	0.436		0.434		0.441	
Age effects when:						
***Age* = 5**	0.2557		0.2434		0.2487	
***Age* = 10**	0.1609		0.1654		0.1678	
***Age* = 30**	0.0764		0.0596		0.0047	
Cohort effects when:						
***Age* = 5**	0.472		0.6763		- 2.7166	
***Age* = 10**	0.922		1.0377		- 1.3482	

Table 4. Exploratory models for the total sample, and final specification for the total sample and elite I (In all cases, productivity is measured according to the *Q* index, and the variable *Young* is equal to one when *Age* ≤ 20)

Dependent variable: Log *Q*

I. KEY VARIABLES	**MODEL 2 T. SAMPLE**			**MODEL 3 T. SAMPLE**		**FINAL SPECIFICATION T. SAMPLE**		**ELITE**	
	Coeff.	***t*-value**		**Coeff.**	***t*-value**	**Coeff.**	***t*-value**	**Coeff.**	***t*-value**
CURRENT JOB = U.S.			**C. JOB = U.S.**						
1. *Brain circulation*	-	-	1. *Brain circ.*	1.0205	2.2*	1.1488	2.6*	0.7678	2.6*
2. *Foreigners*	-0.2626	-0.7	2. *Top 25, Frg.*	0.9418	6.2*				
3. *Stayers*	-0.5536	-1.7	*Young*			1.4311	5.1*	0.3991	3.4*
4. *Top 25 departments*	1.2604	3.2*	*Old*			1.1077	5.6*	0.4391	5.1*
5. *Last 27 departments*	0.6254	1.7	3. *Top 25, Stayers*	0.7366	3.2*				
			Young			1.3196	4.2*	0.3498	2.0*
CURRENT JOB = OSC			*Old*			0.7698	3.0*	0.2908	2.0*
6. *Brain circulation*	0.2139	1.7	4. *Last 27, Frg.*	0.4370	3.1*				
7. *Foreigners*	0.2000	1.7	*Young*			0.9098	3.3*	0.2466	2.1*
8. *Stayers* = Reference group			*Old*			0.6499	3.1*	0.1457	2.0*
			5. *Last 27, Stayers*	0.0168	0.1				
			Young			0.5225	1.7	0.2307	1.4
			Old			0.1019	0.4	0.1236	0.8
			CURRENT JOB = OSC						
			6. *Brain circ.*	0.2134	1.7	0.5914	2.7*	0.2447	2.7*
			7. *Foreigners*	0.1995	1.7				
			Young			0.7261	3.0*	0.2316	2.0*
			Old			0.2704	1.6	0.1230	1.8
			8. *Stayers*	Reference group					
			Young			0.5734	2.4*	0.1221	1.1
			Old				Reference group		

II. CONTROL VARIABLES	**MODEL 2 T. SAMPLE**		**MODEL 3 T. SAMPLE**		**FINAL SPECIFICATION T. SAMPLE**		**ELITE**	
	Coeff.	**t-value**	**Coeff.**	**t-val**	**Coeff.**	***t*-value**	**Coeff**	***t*-value**
A. Demographic variables								
1. *Age*	0.1626	15.2*	0.1628	15.3*	0.1624	15.2*	0.0403	2.7*
2. Age^2	-0.0019	-8.7*	-0.0019	-8.8*	-0.0019	-8.7*	-0.0003	-1.4
3. *Young* x *Age*	0.2242	10.6*	0.2230	10.6*	0.2220	10.6*	0.0111	0.4
4. *Young* x Age^2	-0.0089	-10.4*	-0.0089	-10.4*	-0.0088	-10.4*	-0.0004	-0.3
5. *Young*	-0.3545	-3.1*	-0.3573	-3.1*	-0.7685	-3.5*	-0.1055	-0.7
6. *Female*	-0.5474	-7.3*	-0.5523	-7.3*	-0.5550	-7.3*	-0.1538	-3.3*
B. University of B.A.								
U.S.								
1. *Top 10 U.S.*	0.1476	0.9	0.1406	0.8	0.1444	0.9	0.0790	0.6
2. *Next* 15 *U.S.*	0.0018	0.01	-0.0077	-0.04	-0.0013	-0.01	0.0286	0.2
3. *Next 27* U.S.	0.1326	0.7	0.1499	0.8	0.1530	0.9	-0.0283	-0.2
4. *Other U.S.*	0.0484	0.4	0.0531	0.3	0.0573	0.3	-0.0503	-0.3
Outside U.S.								
5. Reference group = *EU*								
6. *RW*	0.0499	0.6	0.0472	0.6	0.0333	0.4	-0.0550	-1.0

C. University of Ph.D.								
U.S.								
1. *Harvard* & *MIT*	0.2956	3.1*	0.2989	3.2*	0.2903	3.1*	0.0153	0.1
2. *Other Top 10 U.S.*	0.0931	1.1	0.0958	1.1	0.0845	1.0	-0.2138	-2.6*
3. *Next* 15 *U.S.*	0.1064	1.1	0.1097	1.1	0.1062	1.1	-0.1942	-2.2*
4. *Next* 27 *U.S.*	-0.0795	-0.7	-0.0796	-0.7	-0.0924	-0.8	-0.2021	-1.96*
5. *Other U.S.*	-0.1409	-0.8	-0.1320	-0.8	-0.1301	-0.8	-0.0045	-0.03
Outside U.S.								
6. Reference group = *EU*								
7. *RW*	0.4472	3.6*	0.4406	3.5*	0.4548	3.5*	-0.0254	-0.3
D. University of first job								
U.S.								
1. *Top 10 U.S.*	0.2913	3.1	0.2956	3.2*	0.3074	3.1*	0.0919	1.4
2. *Next* 15 *U.S.*	-0.0081	-0.1	-0.0082	-0.1	0.0076	0.1	-0.0099	-0.1
3. *Next 27* U.S.	-0.0634	-0.6	-0.0570	-0.6	-0.0391	-0.4	-0.0528	-0.6
4. *Other U.S.*	-0.1394	-1.2	-0.1394	-1.2	-0.1199	-1.0	-0.0467	-0.5
Outside U.S.								
5. Reference group = *EU* + Missing								
6. *RW*	-0.1557	-1.6	-0.1573	-1.6	-0.1573	-1.6	-0.0543	-0.8
7. *Missing*	-1.5770	-3.4*	-1.5707	-3.4*	-1.6219	-3.5*	-0.4257	-4.5*
Constant	1.9024	10.2*	Constant		1.8145	8.6*	5.459	22.7*
N	2,530			2,530	2,530		833	
Adjusted-R^2	0.549			0.549	0.551		0.317	

Table 5. Tests of hypothesis concerning productivity comparisons between foreigners and stayers. Final specification for the total sample and the elites (productivity measure = Q index, $Young$ = 1 if $Age \leq 20$)

Hypothesis testing, results: **Yes** = foreigners are more productive than stayers
No = foreigners and stayers are equally productive
p**-values** in brackets

		Final specification		
A. DEPT. CATEGORIES	**Model 3 Total sample (1)**	**Total sample (2)**	**Elite (3)**	**Quantile regr. 95th percentile (4)**
1. Top 25 U.S. departments	No (0.2766)			
Young		No (0.540)	No (0.721)	No (0.421)
Old		Yes (0.086)	No (0.263)	No (0.458)
2. Last 27 U.S. departments	Yes (0.0375)			
Young		Yes (0.045)	No (0.908)	No (0.402)
Old		Yes (0.031)	No (0.869)	No (0.594)
3. 29 OSC departments	No (t-value = 1.67)			
Young		No (0.333)	No (0.250)	No (0.278)
Old		No (t-value = 1.65)	No (t-value = 1.80)	No (t-value = 0.31)

B. DEPARTMENT CATEGORIES	**Total sample**	**Elite**
U.S. DEPARTMENTS		
1. Top 10		
Young	No (0.560)	No (0.975)
Old	Yes (0.042)	No (0.140)
2. Next 15		
Young	No (0.441)	No (0.396)
Old	No (0.110)	No (0.356)
3. Last 27		
Young	Yes (0.023)	No (0.704)
Old	Yes (0.017)	No (0.675)
OSC DEPARTMENTS		
4. Canada + UK departments		
Young	No (0.141)	No (0.828)
Old	No (0.912)	Yes (0.066)
5. Other OSC departments		
Young	No (0.744)	Yes (0.058)
Old	No (t-value = 0.71)	No (t-value = 0.08)

Table 6. Descriptive statistics in the total sample. Movers & stayers for different cohort definitions

	Young = 1 if:					
	Age ≤ 15		*Age* ≤ 20		*Age* ≤ 24	
CURRENT JOB = U.S.	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**
1. *Brain circulation*	8	0.3	8	0.3	8	0.3
A. Top 25 U.S.						
Foreigners						
2. *Young*	228	9.0	268	10.6	305	12.1
3. *Old*	156	6.2	116	4.6	79	3.1
Stayers						
4. *Young*	158	6.2	206	8.1	260	10.3
5. *Old*	346	13.7	298	11.8	244	9.6
B. Last 27 U.S.						
Foreigners						
6. *Young*	143	5.6	186	7.3	208	8.2
7. *Old*	117	4.6	74	2.9	52	2.0
Stayers						
8. *Young*	99	3.9	135	5.4	171	6.8
9. *Old*	312	12.3	276	10.9	240	9.5
C. CURRENT JOB = OSC						
10. *Brain circulation*	181	7.1	181	7.1	181	7.1
Foreigners						
11. *Young*	255	10.1	299	11.8	315	12.5
12. *Old*	116	4.6	72	2.9	56	2.2
Stayers						
13. *Young*	202	8.0	255	10.1	304	12.1
14. *Old**	209*	8.3	156*	6.2	107*	4.2
Total	**2,530**	**100.0**	**2,530**	**100.0**	**2,530**	**100.0**

	Percentage distribution between young and old in each category		
A. Top 25 U.S., *Foreigners, Young*	59.4	69.8	79.4
Old	40.6	30.2	20.6
Stayers, Young	31.3	40.9	51.6
Old	68.7	59.1	48.4
B. Last 27 U.S., *Foreigners, Young*	55.0	71.5	80.0
Old	45.0	28.5	20.0
Stayers, Young	24.1	32.8	41.6
Old	75.9	67.2	58.4
C. 29 OSC, *Brain circulation, Young*	59.1	65.7	72.4
Old	40.9	34.3	27.6
Foreigners, Young	68.7	80.6	84.9
Old	31.3	19.4	15.1
Stayers, Young	49.1	62.0	74.0
Old	50.9	38.0	26.0
Total sample, *Young*	**45.8**	**50.1**	**67.1**
Old	**54.2**	**49.9**	**32.9**

Table 7. Tests of hypothesis concerning productivity comparisons between foreigners and stayers for dfferent cohort definitions and productivity measures. Total sample and the elite I

Hypothesis testing, results: **Yes** = foreigners are more productive than stayers
No = foreigners and stayers are equally productive
***p*-values** in brackets

A. Cohort definitions (Q index)

	$Young$ = 1 if $Age \leq 15$		$Young$ = 1 if $Age \leq 24$	
	Total sample	**Elite I**	**Total sample**	**Elite I**
1. Top 25 U.S. departments				
Young	No (0.625)	No (0.948)	No (0.456)	No (0.448)
Old	No (0.127)	No (0.284)	Yes (0.016)	No (0.456)
2. Last 27 U.S. departments				
Young	Yes (0.041)	No (0.933)	Yes (0.027)	No (0.960)
Old	Yes (0.056)	No (0.896)	Yes (0.047)	No (0.780)
3. 29 OSC departments				
Young	No (0.431)	No (0.379)	No (0.147)	No (0.263)
Old	Yes (*t*-value = 2.0)	Yes (*t*-value = 2.3)	No (*t*-value = 0.60)	No (*t*-value = 1.84)

B. Productivity measures ($Young$ = 1 if $Age \leq 20$)

	Q' index		P index	
	Total sample	**Elite I**	**Total sample**	**Elite I**
1. Top 25 U.S. departments				
Young	No (0.591)	No (0.513)	No (0.808)	No (0.960)
Old	No (0.105)	No (0.122)	No (0.244)	No (0.400)
2. Last 27 U.S. departments				
Young	Yes (0.065)	No (0.679)	No (0.509)	No (0.324)
Old	Yes (0.034)	No (0.677)	Yes (0.074)	No (0.964)
3. 29 OSC departments				
Young	No (0.338)	No (0.146)	No (0.825)	Yes (0.082)
Old	No (*t*-value = 1.63)	No (*t*-value = 1.51)	No (*t*-value = 0.37)	No (*t*-value = -0.78)